MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2017/2018

DET5028 – INDUSTRIAL ELECTRONICS

(Diploma in Electronic Engineering)

4 JUNE 2018

2:30 PM – 4:30 PM

(2 HOURS)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **6** pages with **5** questions.
2. Answer **ALL** questions. All necessary working steps **MUST** be shown.
3. Write all your answers in the answer booklet provided.

QUESTION 1 [20 marks]

(a) A Programmable Logic Controller (PLC) program is shown in *Figure 1-1*. For each of the following cases, **explain** and **modify** the rung of the ladder diagram accordingly. **Consider each case separately as they are not related to each other.**

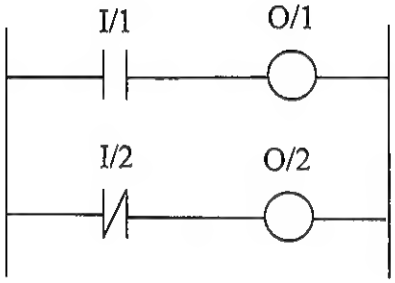

Figure 1-1

(i) How to add a third input (normally-open contact), I/3, in order to perform an AND logic operation to the second rung?

[1 + 2 marks]

(ii) How to latch the first output, O/1, such that, after its input is momentarily pressed, it is still turned on?

[2 + 2 marks]

(iii) How to energize a third output, O/3, in the second rung?

[1 + 2 marks]

(b) Build a PLC program for the following specifications. **The answer should be drawn into a single ladder diagram only.**

A conveyor is run by pressing a toggle switch (its switching action is not momentary). When an optical sensor detects parts carried by the conveyor, the conveyor will stop 3 seconds later. Then, after a delay of 7 seconds, the conveyor will restart and the whole process is repeated. An indicator light will turn on every time the conveyor is running. The conveyor can be stopped manually by releasing the toggle switch.

[10 marks]

Continued ...

QUESTION 2 [20 marks]

(a) In the resistive circuit of *Figure 2-1*, the peak-input voltage is 165 V, the gate-trigger current is 20 mA and $R_1 = 2\ k\Omega$. The firing angle is desired to be 90°. To what value should R_2 be adjusted? Draw the voltage waveforms across the Silicon-Controlled Rectifier (SCR) and across the load.

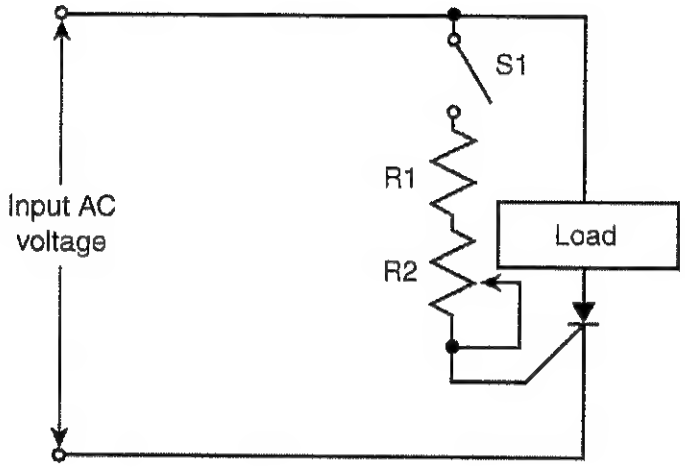

Figure 2-1

[4 + 3 + 3 marks]

(b) Suppose a modification is made to the circuit in *Figure 2-1* so that it looks like the circuit in *Figure 2-2*. The time constant should fall in the range of 2 ms to 40 ms and $C = 0.08\ \mu F$. Calculate the resistances of R_1 and R_2 to give the full firing range of SCR. Draw the voltage waveforms across the SCR and across the load for a firing angle of 130°.

Continued ...

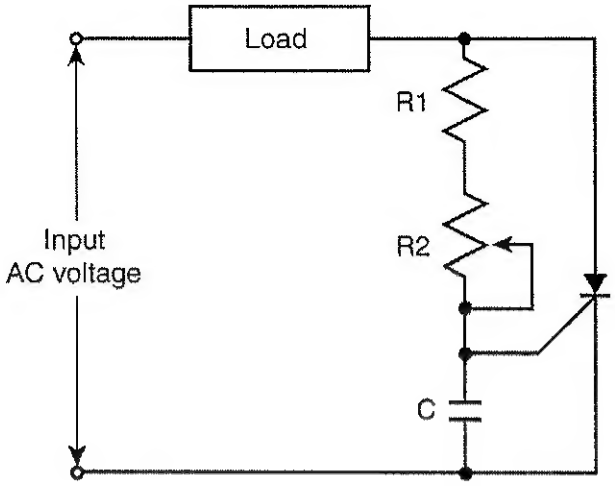

Figure 2-2

[2 + 2 + 3 + 3 marks]

Continued ...

QUESTION 3 [20 marks]

(a) A Resistance Temperature Detector (RTD) with R_T = 140 Ω is placed in a measuring circuit, where the temperature coefficient of resistivity is $\alpha = 0.004/°C$ and the resistance of the RTD at 20 °C is 106 Ω.

(i) Find the resistance of the RTD at 100 °C without any self-heating error.

[2 marks]

(ii) Determine the **maximum current** that can be used with the measuring circuit and the **voltage** across it if the self-heating error is to be limited to 0.4 °C, where the self-heating factor is $F_{SH} = 0.04°C/mW$.

[4 + 2 marks]

(iii) By referring to part (ii), calculate the new resistance of the RTD due to its self-heating problem.

[4 marks]

(b) A strain gauge with an initial resistance of 270 Ω, an initial length of 0.8 m and a gauge factor (GF) of 6 is subjected to a strain of $\varepsilon = 40 \times 10^{-3}$. What are the **new values** of the wire in **both resistance and length** after it is strained?

[4 + 4 marks]

Continued ...

QUESTION 4 [20 marks]

An optical encoder has 45 slit openings on its rotating disc and a direction-indicating ability. Its output is a 10-bit signed magnitude binary, where the 10^{th} bit on the far left is solely used to indicate direction and not used to indicate angular rotation. This 10^{th} bit on the far left represents either sign bit 0 for positive (disc rotating clockwise), or 1 for negative (disc rotating counter clockwise). A large gear on the measured shaft is linked to a small gear on the disc shaft, where the gear ratio is 5 between the large gear and the small gear.

(a) Determine the resolution of the optical encoder.

[2 marks]

(b) Calculate the maximum allowable shaft motion to ensure that the counter never exceed its capacity.

[4 marks]

(c) Find the content of the binary counter if the measured shaft rotates 4/5 turn in counter clockwise direction.

[3 marks]

(d) Determine the amount of shaft **movement** and **direction** represented by a binary output of $[01\ 1001\ 0110]_2$.

[3 + 1 marks]

(e) Calculate the content of the binary counter if the measured shaft rotates 800° in clockwise direction.

[3 marks]

(f) Find the amount of shaft **movement** and **direction** represented by a binary output of $[11\ 0100\ 1111]_2$.

[3 + 1 marks]

Continued ...

QUESTION 5 [20 marks]

A shunt DC motor has an armature winding resistance $R_A = 2.5\ \Omega$ and generates 221.34 V as the armature rotates. It also has an applied voltage $V_A = 230\,V$, a proportionality constant $k_{E_C} = 0.08017$, a field winding resistance $R_F = 148\ \Omega$, a magnetic field strength $B = 1.0827\ T$ and a proportional factor $k_\tau = 0.83$.

(a) What is the motor's output torque?

[4 marks]

(b) What is the motor's mechanical power?

[6 marks]

(c) What is the proportionality factor, k_{E_C}, ?

[4 marks]

(d) Consider that the mechanical load reduces and less torque is required such that the new torque value is 2.7 Nm. What are the new **armature current** and **CEMF**?

[2 + 2 marks]

(e) If the field current is increased to $I_F = 1.74\,A$, the motor will run slower. By using the answer from part (c), what is the motor's new speed?

[2 marks]

End of Page